International Journal of Epidemiology
Vol. 22, No. 1
Printed in Great Britain

Physical Activity and Occupational Risk of Colon Cancer in Shanghai, China

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Using occupational data for over 2000 colon cancer cases diagnosed between 1980 and 1984 in Shanghai, and employment information from the 1982 census for the Shanghai population, standardized incidence ratios (SIR) were computed for occupational groups classified by job types and physical activity levels. Men employed in occupations with low physical activity levels had modest but significantly elevated risks of colon cancer. SIR for jobs with low activity based on sitting time was 121 (95% confidence interval, CI : 108-135) and based on energy expenditure was 126 (95% CI : 115-138). Corresponding SIR for women were 99 (95% CI : 83-118) and 113 (95% CI : 100-127). The data were also used to screen for specific occupations with elevated SIR to generate leads to occupational colon cancer. Increased incidence was observed for professional and other white collar workers, and male chemical processors and female textile workers. The findings add to the emerging evidence that workplace activity may influence the risk of this common cancer.

Colon cancer is one of the leading cancers in the world.[1,2] The incidence and mortality rates of colon cancer, however, are much higher in western countries than countries in Asia, South America and Africa.[3,4] In the US, the colon cancer incidence rate ranks only after those for prostate and lung cancers in men, and breast and lung cancers in women.[5] Even in a low-risk country such as China, this cancer is among the five leading causes of cancer mortality.[6] In Shanghai, the incidence of colon cancer also appears to be on the rise.[1,7] Studies in the nearby city of Hangzhou suggest that general improvement in living standards and adoption of a more affluent lifestyle may have contributed to the rising incidence of this cancer.[8,9]

A number of factors have been suggested to play an aetiological role in colon carcinogenesis.[10-12] Strong evidence is emerging to suggest that high intake of animal fat and low intake of dietary fibre may increase the risk of colon cancer.[9,13-17] Recently, a number of studies have reported an association between low levels of physical activity and colon cancer.[9,15,18-27] Most of the studies,[15,18-27] with few exceptions,[9,28] were conducted in industrialized countries where physical activity levels, including activities at work, may be quite different from those in economically less developed countries.

Although colon cancer generally is not considered as an occupational cancer, excess risk of this disease has been reported in a variety of occupational groups, including workers in the insulation industry, chemical plants, synthetic rubber manufacturing and oil refineries, and wood workers in the automotive industry.[29] Occupational exposures implicated in colon cancer risk include asbestos, synthetic fibre, grain and wood dust, metal dust, cutting oil, solvents, dyes, abrasives, and fuel oil,[29-31] but the evidence available for any of these exposures is still inconclusive.

Using cancer incidence data from the Shanghai Cancer Registry and population data for Shanghai collected as part of the Third National Census in China,[32] the present study evaluates the risk of colon cancer in occupational groups with different physical activity levels and occupational exposures.

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METHODS

Since 1963, newly diagnosed cancer cases from all medical facilities in the 10 urban districts of Shanghai (henceforth referred to as urban Shanghai) have been reported to the Shanghai Cancer Registry,[7] which is a participating registry in the International Agency for Research on Cancer's 'Cancer Incidence in Five Continents' research.[1] For the present study, residents of urban Shanghai aged 30 or over who were diagnosed with colon cancer (ICD-9 codes 153.0–153.9)[33] between 1980 and 1984 were included. Occupation at time of diagnosis, or time of retirement for cases retired at time of diagnosis, was ascertained for 98.3% of the cases by interviewing either the patients (19.7%) or their next of kin or work supervisors (80.3%). Occupational categories and coding were identical to those used in the census.

At the time of the Third National Census in 1982, 1.57 million men and 1.55 million women aged $\geqslant 30$ resided in urban Shanghai.[34] Information on current occupation was solicited on the census registration form and coded, using standardized nomenclature.[35] Occupations were grouped into eight major (one-digit code) categories, 64 subcategories (two-digit codes), and 301 specific job (three-digit code) categories.

The census identified 841 735 retired people. Using a 10% systematic sample of household groups with 10–15 neighbouring household units each, 87 485 people were identified for follow-up interviews.[32] Occupation at time of retirement was successfully obtained from 83 202 (95.1%) people and used to estimate the occupational distribution of all retired people at the time of retirement by age and sex.[32] Occupational classifications at the time of census, therefore, were based on either current occupation for active workers or occupation at time of retirement for retired workers. Tabulations of occupational categories were made for the entire urban population aged 30 years or over by sex and 5-year age groups.

Criteria for assessment of occupational physical activity levels were developed by two of the authors,[36] an occupational physican (RV) and an industrial hygienist (MD). First, a sitting-time index was employed to classify the amount of time in a sitting posture. Jobs with a low activity level were those where more than 80% of working hours (>6 hours a day) were spent seated. Moderate activity was defined as 20–80% of the time (2–6 hours a day) seated, and high activity as less than 20% of time sitting. In general, these categories were chosen to parallel those previously used in occupational physical activity studies.[23,25,26] Second, an energy-expenditure index was adapted from a rating scale developed earlier by measuring energy expenditure for various physical activities under experimental conditions.[37] Low activity was defined as energy expenditure of less than 8 kilojoule (kJ)/min, corresponding to activities such as sitting with only hand movement, moderate working using one arm or light work using both arms (e.g. office work, light sorting work). Moderate activity used 8–12 kJ/min, and included activities walking on a flat surface with an average speed of about 3 km/h, heavy work using one arm or moderrate work using both arms (e.g. picking or sweeping). High activity used an average of more than 12 kJ/min, and included walking on a flat surface with a speed of more than 4 km/h, heavy work using both arms, and light to heavy work using the whole body (e.g. shovelling gravel, or operating a jack hammer). (A complete list of occupations by energy expenditure is available on request.)

Using the above criteria, physical activity levels were assigned to each specific job category, and reviewed by one of the authors (WZ) familiar with occupations in Shanghai and based on a detailed description of type of jobs involved in each category.[35]

Age- and sex-specific incidence rates of colon cancer for 1980–1984 were calculated for urban Shanghai. These incidence rates were then applied to the census-derived age- and sex-specific estimates of person-years in each occupational category for the same time period to obtain the expected number of colon cancer cases in each group. The observed number of cases in each occupation was divided by the expected number of cases and multiplied by 100 to obtain standardized incidence ratios (SIR).[38] Exact 95% confidence intervals (CI) and tests for trends across physical activity levels were computed assuming that the observed numbers of colon cancer cases followed a Poisson distribution.[38,39]

RESULTS

Broad Occupational Groups

Among the major occupational groups, professionals had the highest risk of colon cancer (SIR for men = 135, 95% CI : 119–152; for women = 147, 95% CI : 125–172) (Table 1). Government officials, clerical workers, and commercial and sales workers generally were also found to have elevated SIR of colon cancer, although only for male government officials and female commercial sales workers were they statistically significant. In contrast, the SIR of colon cancer among production and transport workers and female service workers were similar to those of the general population, while among male service workers, the risk (SIR = 65, 95% CI : =54–77) was significantly reduced.

TABLE 1 *Standardized incidence ratios (SIR) for colon cancer by major occupational categories and sex, urban Shanghai, China, 1980–1984*

		Male			Female		
Code	Occupation	No.	SIR	95% CI	No.	SIR	95% CI
0,1	Professionals	264	135	119–152	153	147	125–172
2	Government officials	121	122	101–146	23	95	60–143
3	Clerical workers	86	124	99–153	30	116	78–165
4	Commercial (sales) workers	121	106	88–127	74	132	104–166
5	Service workers	128	65	54–77	142	98	83–116
7,8,9	Production and transport workers	571	90	83–98	514	100	92–109

Detailed Occupational Categories

To explore whether certain occupations may be associated with increased risk of colon cancer, subcategories were examined for the largest broad occupational group (production trades and transport workers) (Table 2). Among men, the greatest increase was found in chemical processors, while low SIR were found among food and beverage processors, construction workers, and transportation equipment operators. The excess among chemical processors arose primarily from elevated rates among petroleum refinery and pharmaceutical workers, but the number of cases of

TABLE 2 *Standardized incidence ratios (SIR) for colon cancer in production trades and transport workers by occupational subcategories and sex, Urban Shanghai, China, 1980–1984*

		Male			Female		
Code	Occupation	No.	SIR	95% CI	No.	SIR	95% CI
7.2	Metal refining and processing workers	26	76	50–111	9	72	33–137
7.3	Chemical processors	19	167	100–260	3	40	0.08–117
7.4	Rubber and plastic product workers	9	95	43–180	26	133	87–195
7.5	Textile workers	55	104	78–135	174	119	102–138
7.6	Leather and fur processors	8	126	55–250	9	129	59–244
7.7	Tailors	14	61	33–102	38	82	58–113
7.8	Food and beverage processors	5	35	11–82	6	69	25–150
7.9	Tobacco product makers	1	56	0.01–309	5	69	22–162
8.0	Wood workers	28	82	55–119	1	18	0.005–99
8.1	Paper and paper product makers	7	139	56–288	26	116	76–170
8.2	Printers	14	133	73–224	7	87	35–180
8.4	Blacksmiths, tool makers and machine-tool operators	68	110	85–139	36	98	69–136
8.5	Precision instrument makers	38	97	69–133	13	101	54–172
8.6	Electrical and electronics workers	37	135	95–186	41	123	88–167
8.8	Plumbers, welders, sheet metal workers	22	95	59–144	12	97	50–169
8.9	Glass workers, enamel and porcelain workers	6	104	38–225	2	48	0.06–172
9.0	Painters	10	83	40–154	4	65	17–165
9.1	Other production and related trades workers	6	48	18–104	18	73	43–115
9.2	Construction workers	6	25	0.09–54	4	65	17–165
9.3	Stationary engine operators	13	83	44–142	1	69	0.02–398
9.4	Material handling and related equipment operators	60	95	72–122	8	59	25–116
9.5	Transportation equipment operators	37	63	44–87	12	123	63–214
9.6	Inspectors and product analysis	18	87	52–137	27	112	74–163
9.9	Other transportation and production	64	102	79–130	32	89	61–125

each was small. Women employed as textile workers had significantly elevated SIR of colon cancer. While a reduction in colon cancer was observed for women in a number of occupations, only SIR for wood workers (one observed case) reached statistical significance (SIR = 18, 95% CI : 0.005–99).

Physical Activity

Men employed in occupations with low physical activity levels had significantly more colon cancer than expected (Table 3). Using the sitting-time index, the SIR for low activity for men was 121 (95% CI : 108–135) and for women, 99 (95% CI : 83–118). Based on the energy-expenditure index of activity, increasing SIR with decreasing activity levels were seen for both men and women, with SIR for low activity of 126 (95% CI : 115–138) and 113 (95% CI : 100–127), respectively.

The excess of colon cancer in low activity jobs was seen regardless of age, but was greater among the retired (age 60 for men and 55 for women) than among current workers of both sexes. Among women who held a high activity job, however, SIR were much reduced before, but not after, retirement. The decreased SIR for men who held moderate to high physical activity jobs were similar before and after retirement (data not shown).

DISCUSSION

The current finding of an inverse association of occupational physical activity levels and colon cancer, from a country where daily living is much less mechanized than in the western world and the bicycle still is the main form of transportation, points to the importance of job-related activity levels as a potential aetiological factor for colon cancer. Considering that an average person spends one-third of his/her time at work, if low-level physical activity is a true risk factor for colon cancer, it is perhaps not surprising that an association between job-related physical activity and colon cancer is observed even in a population with moderate levels of activity outside the workplace.

An inverse relationship between physical activity levels, including job-related activities, and colon cancer has been reported in most, but not all,[28,36,40] previous studies conducted in different populations and employing a variety of study designs.[9,15,18–27,41–43] Although the measurements of physical activity used in a large number of studies were crude, the consistency of findings suggests that physical activity may play an aetiological role in colon carcinogenesis. The mechanisms of effect of physical activity on colon cancer are not clear, although it has been hypothesized that physical activity increases gut motility and decreases faecal transit time,[44,45] and therefore reduces the formation of secondary bile acids, which are cancer promoters, and their contact with bowel mucosa. In addition, physical exercise may have physiological effects on fat metabolism or hormonal changes that modify colon cancer risk.[46]

Our findings on risks of colon cancer by occupational category are generally consistent with those in earlier studies.[26,29] Risks were elevated among professional workers, with no overall excess in production workers, although significant increases were associated with chemical processing among men and textile work among women. Increased risk of colon cancer has been reported among textile and carpet manufacturing workers,[47,48] and among workers exposed to chemicals such as polypropylene[49] and vapour-phase ethyl acrylate and methyl methacrylate monomer,[50] although evidence for these associations are inconclusive.[29,51–53] In addition, we found a significantly decreased risk among food and beverage processors,

TABLE 3 *Standardized incidence ratios (SIR) for colon cancer by occupational physical activity index and sex, Urban Shanghai, China, 1980–1984*

Activity index	Activity level	Male			Female		
		No.	SIR	95% CI	No.	SIR	95% CI
Sitting time	Low	319	121	108–135	129	99	83–118
	Medium	448	95	86–104	337	108	97–120
	High	526	94	86–102	470	100	91–110
				P for trend = 0.001			*P* for trend = 0.7
Energy expenditure	Low	467	126	115–138	289	113	100–127
	Medium	603	91	84–99	552	102	94–111
	High	223	85	74–97	95	83	67–101
				P trend = < 0.001			*P* for trend = 0.01

whereas an increased risk for food manufacturing workers was reported in a study in the US.[26] While the moderate level of physical activity of food and beverage processors in our study might have reduced their risk of colon cancer, it is also possible that these apparently similar job classifications in the two countries actually involved different activities and exposures.

Although the current findings on physical activity at work and risk of colon cancer tend to support those of earlier investigations, a number of limitations in this study should be noted. Occupation was ascertained at one point in time, i.e. at time of diagnosis or retirement for cases and at the time of census or retirement for the general population. Since job mobility in China in the early 1980s was still quite limited, particularly for older individuals, this single occupation ascertainment is generally considered to be a valid indicator of usual occupation. Occupations were validated for 306 male and 104 female randomly selected cases who were alive at the time of census. Agreements on one-digit and two-digit occupation categories between the census and survey information, and between personal and proxy survey information, were generally well over 90% and there was 85% agreement for occupations at the specific three-digit level.[32] In addition, because of the intimate and long-term work relationships among Chinese workers in the early 1980s, work supervisors were usually very familiar with the workers' occupation and had access to factory records regarding the workers' employment histories. Previous studies have also shown a high degree of agreement in personal and spouse-reported usual or last occupations[54] and agricultural pesticide exposures.[55]

The occupations of retired people were estimated from a 10% random sample of retired subjects by interview. Examination of the 10% sample revealed a distribution representative of retired subjects in the 10 urban districts included in the current study. A comparison of SIR for several common cancers in the current data, including stomach, lung, and breast cancers, between retired and current workers in a number of occupations also showed consistent results.[32] The association with physical activity among men over the retirement age (age 60) suggests that the protective effect may persist for some years even upon cessation [illegible] expenditure, although people among professionals and government officials may be related to their sedentary occupation, it is also possible that these occupational groups, because of their higher socioeconomic status, have a more affluent lifestyle, including greater consumption of meat and perhaps higher body mass index. Non-occupational or post-retirement physical activities were not ascertained. In urban Shanghai prior to the early 1980s, leisure time physical activity and exercise were not common or popular. Variation in non-occupational activity levels therefore may be low among the general population. Likewise, the consistency in our findings among both men and women and with other studies lends support to the association between occupational activity levels and colon cancer risk, regardless of the non-occupational activity levels which may differ between men and women (e.g. amount of housework).

In addition, because of the limited information available for this study, only relatively crude measurements of physical activity were used. Also, because of small numbers of cases in the occupation subcategories and the specific job categories, and because a relatively large number of comparisons were made, chance variations in the SIR cannot be ruled out.

Despite these limitations, the findings from this large, systematic investigation in an industrial city in China of an inverse association of physical activity and colon cancer risk support results from a number of other studies, and warrant further investigation into the patterns of physical activity and the mechanisms by which physical activity may affect colon cancer risk. Our findings of increased SIR for colon cancer in certain occupational groups (such as chemical processor and textile workers) add to the limited evidence of a potential role for occupational exposures in colon carcinogenesis. These findings, however, await confirmation by studies that can examine these associations with detailed assessment of exposures and potential confounding factors.

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(Revised version received August 1992)